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ABSTRACT

This review and synthesis focuses on issues concerning the relationship between basic mathematics competency and vocational education. A section which outlines the problem--the lack of basic competency in computational skills in youth and adults--discusses the work of the National Assessment of Educational Progress to evaluate student performance and declining scores on Iowa Tests of Basic skills and California Achievement Tests. Support for remedying skill deficiencies is described as coming from implementing career education in the mathematics classroom and the public's support of increased emphasis on careers in high school as shown by the Phi Delta Kappa based on Gallup Polls of Public Attitudes Toward Education. A section that makes special note of the problem of defining "basic skills" suggests that skills can be specified only as being basic when that to which they are basic is specifically stated. The need for vocational educators to search for and specify the mathematical applications that underlie vocational emphasis is briefly considered. The section following provides examplars of the varied approaches of mathematics and vocational educators to the issues of mathematics in vocational curricula, individualization, metrication, and instruction for special needs groups. Concluding lists of observations and recommendations summarize the information presented in the monograph. (YLB)

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Information Series No. 199

BASIC MATHEMATICS SKILLS AND VOCATIONAL EDUCATION

written by

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FOREWORD

Recent legislation and funding allocations provide evidence of a strong commitment to basic skills education on the part of the federal government. The Basic Skills Act passed by Congress as Title II of the Education Amendments of 1978 is the major legislative mandate under which grants for basic skills education are being administered.

Such activity at the federal level is reflective of public concern over students' declining test scores on national assessments of reading, writing, and mathematics skills. The yearly Gallup polls of public attitudes toward education sponsored by Phi Delta Kappa have shown a continuing concern over the need for more instruction in the basics. The 1979 edition of The Condition of Education by the National Center for Education Statistics showed that secondary school principals report increased emphasis on basic reading, writing, and mathematics as the greatest change in the schools in the past five years.

This emphasis on basic skills education exists in vocational education as well. Basic skills education has been a national priority theme in vocational education during the past year and promises to be of continuing concern in the future. For vocational educators, however, the term basic suggests basic to an occupation. The focus of basic skills for the vocational educator, therefore, is on those competencies required for success in an occupation. This paper provides vocational educators with an overview of the issues involved in the relationship between basic mathematics skills and vocational education.

"Basic Mathematics Skills and Vocational Education" is one of six interpretive papers produced during the second year of the National Center's knowledge transformation program. The review and synthesis in each topic area is intended to communicate knowledge and suggest applications. Papers in the series should be of interest to all vocational educators including teachers, administrators, federal agency personnel, researchers, and the National Center staff.

The profession is indebted to Dr. Thomas E. Long for his scholarship in preparing this paper. Recognition is also due Dr. Linda Reed, CEMREL, Inc.; Ms. Savannah Miller-Young, St. Louis, Missouri Public Schools; and Dr. John Peterson, the National Center for Research in Vocational Education, for their critical review of the manuscript. Dr. Carol P. Kowle supervised publication of the series. Mrs. Ann Kangas and Mrs. Margaret Starbuck assisted.

Robert E. Taylor
Executive Director
The National Center for Research
in Vocational Education

> At first you don't realize you are going to fail. You sit in class while the teacher is explaining things and you just don't understand what she is talking about. You ask a question or two and the teacher gives you the answers, but you still don't understand . . . you feel kind of ashamed to keep asking questions; it makes you feel like you're dumb. . . . I was hoping that we would get on to something new that I would understand better, but it didn't work out that way.
>
> Quote from a high school student in a report to the New Jersey Department of Education.
>
> "Who Failed?" in Saturday Review.

INTRODUCTION

To the American public, mathematics is generally considered as a basic academic skill, a skill essential for optimum efficiency in social, consumer, economic, and occupational endeavors. As such, it follows that formal education is expected to provide sequential experiences to help learners develop the basic computing skills as well as other mathematics capabilities that individual students might be inclined to develop. The acquisition of personal computing skills is highly related to one's subsequent vocational development. Some authors have plumbed the relationship between mathematics competency levels and careers. Among these have been Long, Shoemaker, Smith, Veselko, and Gates (1975), the team of the National Council of Teachers of Mathematics, who wrote about career education in mathematics classrooms. Such writers suggest that mathematics instruction, among other things, should be basic to, supportive of, and allied with curricula directed toward the development of vocational and occupational specialties.

Eschenmann and O'Reilly (1979) described prevocational skills as those capabilities which identify the readiness of a learner to profit from vocational education and stated that those skills can be considered course prerequisites, as many of them are learned through schooling. They further stated that occupational prerequisites specify where occupational instruction should lead. If school experiences do not provide students with necessary prevocational skills, their occupational development will suffer. In describing a curriculum model for occupational preparation, Williams (1979) discussed job-seeking, job-keeping, and occupational skills. In terms of basic skill development, one readily sees the cogent relationship among these skill levels.

As typically delivered to American youth, however, mathematics instruction begins early in life and thus precedes formal vocational decision making and specialization. Thus, mathematics is a prevocational curricular experience which has subsequent rigorous and undeviating implications for curricular decision making related to occupational specialization. While early mathematics instruction is largely prevocational, such instruction can also be co-vocational. Kaufman, Schaefer, Lewis, Stevens, and House (1967) found differences in modes of delivery of mathematics instruction to vocational students. Some instruction was provided in the shop or laboratory by the vocational teacher. Other instruction was offered outside the laboratory block of time by a special related-subjects teacher or by a purely academic teacher. Mathematics skill development can also accompany the decision-making, preparation, and occupational entry stages as they recur throughout life for older youth and adults.

The third of the three Rs, "rithmetic" or computing skill, marches in an eminently powerful position among other cognitive skills when specialty curricula of all types and levels are considered and chosen. The level of mathematics competence acquired has its continuing effects on each of us. In truth, mathematical capability affects kids of all ages. Consequently, the relationship between computing capability and vocational education deserves the attention of specialists in both disciplines.

This monograph addresses the issues concerning the relationship between basic mathematics competency and vocational education. It notes the decline in basic mathematics skills in American society and the pervasive desire of citizens to reverse that trend.

Special note is made of the problem of defining the term basic skills. The point is drawn that skills can only be specified as being basic when that to which they are basic is clearly stated or identified. That is, skills are either basic or not basic to a specific occupation.

Busy administrators and teachers will find this not to be an encyclopedic listing of skills needed in specific occupations. (Some citations, however, will assist them in such a search.) Instead, they will find exemplars of the varied approaches of mathematics and vocational educators to the issues of mathematics in vocational curricula, individualization, metrication, and instruction for special needs groups, among others.

The reader will also find suggestions for research, as well as for the use of the ERIC and other concept-rich information systems.

THE PROBLEM

Unmet Needs

In spite of the need for competence in basic academic skills, for work among other purposes, a large cohort of students exists which needs special attention in remedying basic mathematics deficiencies. Various professionals cite these students as being those who have mathematics anxiety, who experience math-phobia, who have suffered mathematics trauma, or who have restricted their development by avoiding mathematics instruction because of a personal mathematics filter. In these cases, personally or externally caused, the effects are the same--mathematical incompetence. Regardless of cause, the cohort of the mathematically deficient is large and it needs attention. As noted in its Databook (1976), the National Institute of Education (NIE) earlier in this decade listed basic skills as a priority funding area. Yet, actual amounts of money budgeted for basic skills declined from 1973 to 1975. In 1973, $19.3 million were allocated; this dropped to $12.4 million in 1975. Those monies were to be used for research to discover what reading and mathematical skills are required for adequate functioning in society, how children can overcome barriers to learning the basics, and how the teaching of reading and mathematics can be improved.

The National Institute of Education today is involved in many efforts related to the basic skills. In mathematics, for example, the NIE funds the Research and Development Interpretation Service (RDIS) project in elementary school mathematics at CEMREL. The goal of the project is to transform research knowledge into information which will help mathematics teachers make wise instructional decisions.

National Assessment of Educational Progress Data

The problem is still with us and the work of the National Assessment of Educational Progress (NAEP) gives some idea of its extent and seriousness. In reporting on NAEP data related to elementary school children, Carpenter, Coburn, Reys, and Wilson (1975a) noted weakness in student performance in computations involving percents, development of fractions concepts, complex work problems, measurement tasks, and the understanding of geometry topics. They stated that thirteen-year-old children performed at about the same level as adults in whole number operations. One might wonder--is that evidence for quality in thirteen-year-olds or evidence of frustration in adults. In a similar article, Carpenter et al. (1975b) related NAEP data to the secondary school. They stated that implications for improvement in mathematics programs were abundant in the NAEP

data. They reported specific needs for work on problem-solving skills checking the reasonableness of computational results, estimating, fractions, and percents. In coping with these problems, they called for suggestions from and collaborations with teachers, educational leaders, curriculum workers, as well as mathematicians.

When NAEP data from the 1973 and 1978 mathematics assessments were compared, it was found that the skill level of nine-year-olds did not change. The skill levels of thirteen- and seventeen-year-olds, however, declined significantly in the 1978 data. The seventeen-year-olds showed the largest drop. Since most children eventually enter the work force, and since vocational education is related to preparation for some levels of work for many students, it seems that mathematical and vocational educators have reasonable need and ample opportunity to collaborate in attempts to make mathematics instruction more practical and relevant for vocational students.

Other Evidence of Need

Other evidence of need for attention to basic skills is noted. Munday (1979) reported Iowa Tests of Basic Skills grade equivalent data for 20,000 youngsters after he compared their 1970 and 1977 test performances. Even for bright students in the eighth grade, he found a loss of over half a year in performance on mathematics concepts. He also concluded that the decline in school achievement had leveled off. Cooperman (1979) felt that the mathematics achievement decline continues, and advanced figures related to the standardization of the California Achievement Tests, also done between 1970 and 1977, which show that at the eighth grade level, mathematics achievement declines at the rate of 3.5 percent of a standard deviation per year. Brantner and Enderlein (1973) studied variables related to the prediction of potential dropouts in vocational programs. Among other findings, they found a significant difference between vocational retainers and vocational dropouts on General Aptitude Tests Battery numerical scores. Maffei (1978) surveyed 600 high school mathematics teachers and from that research reported several causes of declining mathematics scores. Three related to problems with basic skills. He felt that: (1) mathematics curricula place less emphasis on basic computational skills; (2) teachers place less emphasis on teaching basic computational skills; and (3) mathematics curricula are more likely to make explanation of problems unclear by using too much formal language and abstract symbolism.

Heimer (1969) felt that efforts to build curricula in mathematics demand decisions about the structuring, content, and designing and ordering of instructional tasks. One might speculate that of those students who exclude themselves from mathematics courses,

presumably restricting their mathematical competence, many may do so because they find little gratification in mathematical activities. If so, the findings of Maffei may relate to the findings reported by Grasso and Shea (1979) who documented data by curriculum and sex for thousands of high school students and the subjects they "liked" and "disliked the most." At most, only about one fourth of any group chose mathematics as the subject most liked.

In a Nutshell

The problem, briefly stated, is that youth and adults need at least basic competency in computational skills, skills which all too many citizens today simply do not possess. It is disputable that such individuals do not realize or care that mathematics is an auxiliary symbolic language, one which enables further and different types of communication and information processing. It is indisputable that those who do not possess skills in that communication system are disadvantaged when they need them and when they compete with those who do possess them. It is axiomatic that the more people know about their work, and the more symbols they can use, the more they can manipulate and control their occupational development and destiny. Jencks (1972) stated that when a person's cognitive skills are below national norms, that person is at a significant disadvantage--economically, socially, and psychologically. Pucel (1972), in discussing the individual and that individual's choice of occupation, noted that lack of skill causes problems when the individual is specifying and preparing for that occupation. He stressed the need for assisting students who do not have sufficient skills to enter appropriate training programs. In a related vein, Brandon (1971) noted the fact that the academic, liberal, and vocational segments of education have not formed a mutually supporting mix. He felt that academic disdain for the practical in education persists. More recently Mote (1976), in citing the need for competence in academic subjects and basic skills, emphasized the need for cooperation between vocational and academic educators. She made suggestions for making academics a vital and respected curricular ally of vocational endeavors.

The time seems ripe for change. Evidence of social and occupational limitation related to mathematical diffidence is maturing. Conditions are spurring us to action. Co-curricular synergy and teamwork are needed, at least as accented here, between mathematics and vocational educators.

SUPPORT FOR REMEDYING SKILL DEFICIENCIES-- CONCORDANT AGREEMENT

In writing about the American educational structure, Lathrop (1974) noted that it is reasonably safe to say that most students' decisions are made in terms of high school graduation rather than in terms of life-oriented goals. He also stated that since most youth leave formal education at grade twelve, the making of educational decisions in terms of the short-range goal of graduation seems woefully inadequate. He expects that education will support a continuing commitment to intellectual and vocational self-renewal. Education, he feels, is at a turning point. Either it must admit to a limited role in an individual's development or it must reorganize itself to deliver the results that it has long claimed. It cannot, he feels, expect to be supported on one basis and deliver on another.

Rhodes (1969) felt that the amount of secondary school practical mathematics could be increased if it were related to a job training program. He noted that such mathematics might not be "rigorous" in terms of the gifted, but it would be "useful and remembered" by those putting it to practical use in school and on the job.

Career Education

The career education movement which embraces all of education seems to address the issues noted by Lathrop and Rhodes. It is a concept which seems to have the support of the general public and the educational community, including many vocational and mathematics educators in particular. It is appealing in that it embraces vocational, academic, and liberal education, and encompasses each insofar as it promotes understanding of the relationships between what one learns and the world of work tasks for which the learning is requisite. When an instructor thinks of subject matter in relation to its utility and relationship to work, and reorganizes instruction to deliver those emphases in addition to the substantive content of the discipline, that teacher is as much a career education teacher as the teacher of a vocational specialty.

Hoyt (1976), in discussing the importance of the teacher in career education, notes that many things happen when teachers relate subject matter to careers. Students learn more and teachers are offered opportunities to reorganize the substantive content of what they teach. He cites an elementary teacher who said that while increases in basic skills may well represent a major goal of the teacher, it is unlikely to be the major goal of most students. The students are "turned on" by the career

education instructional activities, not by feeling that because of them they will learn more subject matter.

It is a truism that it is not the content but the purpose of the learner which makes a course vocational. Since most students hope to prepare for a work life, and since the work world is so diverse, all courses have occupational significance for some students. When optimum achievement is not accomplished in any area of study, the student is deprived of the development of significant potential. When such remission is at the basic skill level, the person is inept for further study in that area and for work requiring the forfeited skills. It is, after all is said and done, people who are unskilled, not occupations.

The career education movement has much support from the legislative community. Perkins (1976) stated that, in his view, career education programs have proven their worth and should be implemented across the nation. As noted, the mathematics community also seems to support the concept. The Editorial Panel of The Mathematics Teacher (1976) reported the findings of a preliminary survey of mathematics teachers, supervisors, and teacher educators regarding career education issues. The results to eleven of the statements posed were supportive of the concept. One statement, however, "Mathematics teachers understand the career implications of their subject and can implement career education without extensive retraining," showed 75 percent of the respondents disagreeing with the item. Those responding felt that teachers need more information about occupations and mathematics uses in trades and professions. Another finding of interest is the response to the item "Stressing career education in mathematics classes will lead to more effective teaching of skills and concepts." Sixty-four percent of the respondents agreed. Vocational educators and teachers of occupational specialities should find encouragement and support for renewed basic skill treatment in this study. In addition, if vocational specialists are truly interested in coaction with their academic peers in modifying mathematics instruction in career-related directions, they would find support for pursuit of such endeavors in the data.

Finn and Brown (1977) felt that mathematics teachers, by implementing career education in the classroom, can help achieve mathematics objectives, as well as helping students explore the world of work and the mathematics needs of various occupations. Fishman (1971) felt that mathematics teachers have special responsibilities to students who are learning mathematics in relation to vocational programs. Hershkowitz, Shami, and Rowan (1975) reported on a Maryland study in which it was found that citizens want more relevance in the curriculum. The authors felt that the present interest in career education can be expected to give clearer direction toward accomplishing that goal. The

investigators reported that mathematics for mathematics' sake is not, relatively speaking, important to the public. Peterson (1976), guest editor of a special issue of School Science and Mathematics on career education, noted the differences between utilitarian goals of mathematics education and the social, cultural, and personal goals of individuals. The latter cluster included attitudes towards work, decision making, and career information which he felt needed to be integrated into mathematics and science classes.

Phi Delta Kappa--Gallup Polls

Related to career preparation, basic skills education and its mastery, further support is found in recent Phi Delta Kappa supported Gallup Polls of Public Attitudes Toward Education.

In the sixth poll in 1974, 90 percent of the national sample wanted to hold back students who were not able to keep up with their classmates and who failed in their work (Gallup, 1974, p. 29). In the seventh poll in 1975, 22 percent of the sample felt that declining performances on tests given to students were due to a curriculum which is too easy with not enough emphasis on basics (Gallup, 1975, p. 235).

In the eighth poll in 1976, 80 percent of the national sample wanted more emphasis on careers in high school. Fifty-two percent of the sample also felt that more information about jobs and careers should be given in the elementary school curriculum (Gallup, 1976, pp. 191-192).

Eighty-three percent of the sample in the ninth poll (1977) favored the back to the basics movement (Gallup, 1977, p. 36).

In the national public's ranking of what it felt schools should be doing but were not doing, "back to basics" ranked third of seven items in the tenth poll reported in 1978. When those who had finished high school ranked high school subjects or experiences most useful in later life, mathematics ranked second and shop ranked fifth of ten items ranked. When ranking subjects that were offered in their high school and which would now be of special help, but were not chosen by the respondents, mathematics ranked second and shop ranked third of ten subjects listed (Gallup, 1978, p. 44).

In the eleventh poll in 1979, mathematics was the top rated school subject on essentiality. Ninety-seven percent of the total sample deemed it as essential. In rank order of things parents disliked about their children's schools, they listed "not enough emphasis is placed on the basics" as second (Gallup, 1979, p. 43).

For the past several years the messages seem to be consistent. Parents want basic skills emphasized, they want those skills mastered, and they want education to be related to work. They seem to want mathematics, in particular, to reflect the "real" world, not just the abstract concepts of numeration. Teachers, when developing course materials and experiences which utilize life problems and examples, should stress the realness, the absolute cogency, of mathematics and that of schooling itself. Neither is an artificial or illusory experience. Both are substantial endeavors which prepare people for subsequent authentic life stages and roles.

Informed citizens are united in agreement on the saliency of these issues. That is, the basics are important! The cry for attention to them seems to be a curricular subpoena.

THE CURRICULAR DILEMMA--WHAT ARE THE BASICS?

As was found in the ninth Gallup poll of Phi Delta Kappa (Gallup, 1977) there is discrepant understanding among the public about what basic education means. Most regard the basics as reading, writing, and arithmetic. Others tend to aggregate additional subject areas with the three Rs, and still others interpret the term to mean a return to schooling styles of earlier times. In relation to mathematics, the public often views the basics as a set of discrete concepts or skills to be incorporated by learners for day-to-day use. Mathematicians, as might be expected, view it much differently and much more broadly.

Much to its credit, the National Institute of Education (NIE) conducted a conference on Basic Skills and Learning in 1975, and produced two volumes of conference reports for professional use. Volume I (NIE, 1975a) presents position papers on the basic mathematics skills and learning. Volume II (NIE, 1975b) presents working group reports. Vocational educators who are concerned about mathematics instruction, and interested in fostering collaborative activities with mathematics teachers related to mathematics instruction as it applies to vocational education, should read these documents. Begle (1975), in one of the thirty-three position papers found in Volume I, considered basic skills as those that are likely to be used by the average citizen in everyday life. Branca (1975), in discussing the objectives of mathematics education, felt that most objectives could be classified under either of two major emphases: (1) utility of mathematics for individuals and society, and (2) understanding and appreciation of the nature and significance of mathematics as an abstract system.

Braunfeld (1975) described basic mathematics, and believes in the validity of it, as a basic tool for the following reasons:

1. Mathematics is a tool for everyday life.

2. Mathematics is a preparation for a variety of future careers.

3. Mathematics is a vehicle for generating and exercising critical thinking and problem-solving abilities.

4. Mathematics is done for its own sake as a stimulating, rewarding activity in itself. (p. 23)

Fey (1975) stated that the challenge to describe basic skills in mathematics is an assignment full of pitfalls and that most attempts to establish reasonable lists end in failure. He also felt that the use of lists as curricular guidelines threatens to produce fragmented programs that resemble occupational trainings rather than education in mathematics methods and understandings that have potential for long-range value.

Gibb (1975) saw four areas of basic skills in mathematics: (1) understanding of mathematical concepts and techniques of computation; (2) skills in using these understandings in computation; (3) skills in problem solving, and (4) skill in thinking creatively (p. 57). She stated that she had not attempted to list what everyone should know in mathematics. Rather, she feels that all students have the right to learn mathematics according to their individual capabilities and must be given support so that they can learn; that roads be kept open in making decisions for careers, and that education in mathematics should provide as many career options as possible.

Rising (1975) stated that it should be evident that any basic skill is a multivariate function and cited the following independent variables:

1. Time -- basic skills of fifty years ago are not those of today, and today's skills will probably not be those of a decade in the future.

2. Place -- rural and urban skills differ.

3. Age -- school age skills or pseudo-skills are quite different from the skills necessary to function as an adult.

4. Occupation -- the skills appropriate to a housewife are quite different from those necessary to a medical technician. (p. 148)

In a footnote, Rising defined pseudo-skills as those directed at test-passing rather than real world application. He felt that a job entrance exam may or may not be a measure of pseudo-skills.

The above paragraphs sample representative views concerning basic skills in mathematics as found in the position papers of mathematics professionals. The reader of the NIE reports will sense the challenge, dilemma, futility, and possible chaos in trying to specify "basic mathematics skills." Technically and mathematically oriented people believe in the solvability of problems. Finding adequate solutions to this one will test their mettle.

The reader interested in other positions and concerns related to basic mathematics education might refer to Brown and Kinney (1975), Hiatt (1979), Rauff (1979), Smith (1978), and Trafton and Suydam (1975).

Considering the quandary related to specifying the basics of mathematics, Braunfeld (1975) brought some order to the confusion by noting that the word "basic" is probably not a property of something, but expresses a relationship between two things--for example, "x is basic to y." He noted that one frequently hears, "x is basic." However, if said by a careful speaker, then either the "to y" is clear from the context, or there is an enormous range of ys. He felt that in trying to sort out what are, or should be, the basic skills in mathematics, we first must be clear about the questions: basic to what end and for whom. He further stated that:

> The utility of mathematics in a variety of socially useful and important vocations is often adduced as the most important reason for including it in the school curriculum. Whether or not this argument is valid, surely the historical reason for the extensive concern with teaching mathematics in school is precisely that it is needed for numerous professions and trades. (p. 26)

Generally speaking the working group reports, in Volume II of the NIE (1975b) documents, noted the value of mathematics to consumers and workers. Hilton and Rising (1975), cochairmen of the conference, warned educators, however, against assuming that mathematics which is not going to be directly applied would or should forfeit its place in the curriculum.

Again many messages seem evident. Mathematics is an area of study capable of supporting supremely sophisticated and abstract conceptualization, and those higher levels of activitity are predicated on the mastery of simple, basic, yet precise competencies. Then, too, we sense that most students in vocational education do not deal with the higher, more abstract,

mathematical processes; yet they need keenness in those simpler, exact, and unerring processes, and those skills are generalizable to many occupational settings. Although these perceptions are unclouded, the dilemma remains. What are the basic mathematical processes? Better questioned, in Braunfeldian terms, what are they for specific occupations or clusters of occupations?

WORK BEYOND THE HORNS OF THE DILEMMA

Vocational educators and mathematics educators are alike in recognizing the value of generalized mathematical competence. Long and Herr (1973) noted that while mathematics teachers are competent in knowing the levels of mathematics required of mathematically oriented professionals, as well as those reflected in college admission requirements, they are not equally competent in specifying the mathematics that are important for skilled and craft occupations, or the vocational courses that are required for entry into those occupations. Those perceptions were reinforced by the survey data of the Editorial Panel of The Mathematics Teacher (1976) reported earlier.

Moreover, vocational educators do not wish to dismember the mathematics curriculum or reduce its value for the comprehensive development of an individual's talent. They have no desire to dichotomize mathematics content into useful versus useless, and applied versus intellectual categories. Vocational educators must, however, search for and specify the mathematical applications that underlie vocational emphasis--those irreducible elements (basics) of computing competence needed for success in the specialties they teach.

Long and Herr (1973) noted that there is a pattern of need for more complex mathematical skills as one moves from craft and skilled areas to more technically oriented specialties. At every level, in all areas, vocational educators want to know, to the extent possible, what competencies are needed for optimum success, so that they can assure themselves and subsequent employers of their students that those skills have been mastered by the learner.

While a canon of belief among educators is that there are differing computing skills needed in various occupations, the mathematics of most concern to vocational teachers, and to employers of their products, and those skills cited as being in need of most remediation, are the more fundamental computing functions. In writing about the goals of education, Klaurens (1975) noted the priorities of business and industrial leaders. She indicated that it is not surprising to find that group ranking fundamental skills at the top because of the problems

encountered with employees who are not capable in simple mathematics or who cannot spell commonly used words.

It may be that a student, reasonably prepared in the basics, can readily learn the occupationally related mathematics required in conjunction with vocational instruction. Regardless, many individual vocational teachers and schools have been engaged in occupationally related basic mathematics studies, curriculum developments, and instructional efforts. Vocational teachers have personal urgings and professional exhortations to do so. In that regard, Cross (1975) stated that vocational specialists have in the past assumed that basic skills were the province of general or academic educators, but they are now recognizing that those skills must be developed in vocational programs if they do not already exist.

Romberg (1969), a decade ago, noted that although it had long been assumed that studying mathematics was useful (if not necessary) for many activities, not much had been done to validate that assumption. He stated that not a single study on the utility of mathematics to learning tasks outside mathematics was reported since the review of research in mathematics prior to his work was reported.

Boyer, Waters, and Harris (1978) stated that historically the public school curriculum has been a responder rather than an initiator. It tends to react to pressing human problems. The budding recent alliance between mathematics and vocational educators related to basic skill development in students seems to hew to that line. It is still heartening to note that the ERIC system is replete with notations of activities related to basic skill development in mathematics in vocational education.

DETERMINING OCCUPATIONALLY RELATED BASIC SKILLS

Some basic mathematics inquiries have been specific to certain of the occupations; others have been general and have been directed to many occupations. Examples of the occupationally specific type include the determination of mathematics' role in electrical and electronic technologies (Barlow and Schill, 1962), and Johnson's (1972) analysis of competencies necessary for certain technician level health occupations. Long and King (1975) reported mathematics needs in relation to high school business education programs. Bookhammer (1974) studied the mathematics utilized by area vocational-technical school graduates of electronic technology programs. King and Long (1976) discussed mathematical skills in relationship to secondary school health occupations trainees.

Other investigators have looked at mathematics skill needs in a variety of disciplines. Rahmlow and Winchell (1966) identified clusters of mathematical skills needed in occupations available to noncollege-bound youth. Fitzgerald (1976) discussed 44 mathematics competencies needed by workers entering technical occupations after completing secondary schooling. Kawula and Smith (1975) studied skills generic to 82 different occupations in Saskatchewan. Mathematics was one of the skill areas addressed. Long, Enderlein, Ford, and King (1973) determined teacher-perceived student need for the basic mathematics skills for Pennsylvania secondary students in 61 vocational specialties. For each specialty, they also determined the need for remediation of each of the 66 mathematics skills. Later, Long (1979) studied the same 66 skill needs and the need for remediation, as perceived by employers, of newly graduated students of secondary vocational programs. A series of studies in Pennsylvania, related to the 1973 work of Long, was done concerning mathematics skills of various subpopulations of vocational students and include Brouse (1977), Caruso (1975), Fochler (1977), Robinson (1978), and Runkle (1978).

Development of Curricular Materials

While some mathematical and vocational investigators were engaged in studying fundamental skill needs in relation to occupations, others were developing curricular materials which addressed the mathematics deemed basic to various vocational specialties. Caldwell, Daniels, Miller, and Reid (1972) developed a secondary mathematics curriculum using many supplementary materials. It is interesting to note that their work produced two program sequences, one for vocational and one for college preparatory students. The District of Columbia Public Schools (1977) developed a curriculum guide related to mathematics for everyday business, personal use, and fields of employment. It begins with basic mathematics and pursues thirteen additional business and consumer mathematics units. Bogdany (1976) produced a curriculum guide for mathematics fundamentals related to the baking occupation. Kaffine and Paulsen (1971) studied the appropriateness of high school mathematics curricula for postsecondary VTAE students. They provided recommendations for development of mathematics offerings for vocational-technical students.

Individualization

Recognizing that the mathematically deficient cohort needs service and, also, that the decision to learn or remedy mathematics skills is an individual one, many curricular workers have produced individualized materials. There have been several

large enterprises in this area. Rahmlow (1968), for the Washington State Coordinating Council of Occupational Education, led the development of twenty-one programmed instruction books for learning occupationally related basic mathematics. Mathematicians and vocational educators were joined by tradesmen in the production of the materials. Cosler (1974) served as editor for the production of individualized mathematics problems for the Oregon Math Council, and the Career and Vocational Education Section of the Oregon State Department of Education. She and her colleagues developed eighteen sets of individualized mathematics problems related to diverse occupations.

The Dorchester, South Carolina Vocational Center (1978), using vocational and mathematics teachers working together, developed more than 200 learning packets which combined use of individualized techniques and related vocational information. The packets were used to teach mathematics skills in fifteen vocational areas after minimum competencies in each of the areas were determined. Maloyed and Hedinger (1971) developed review lessons relating basic mathematics to the work of electrical apprentices and vocational students and to the electrical code. Herr (1976), for the New Jersey State Department of Education, Vocational Education Division, produced a basic mathematics operations practice booklet as one of several mathematics practice books. The materials were developed for student use in vocational high schools.

Metrication

Metrics, an area of developing concern to mathematics, science, and vocational education, has been addressed by representatives of all groups. Exemplars of that work, which are related to vocational study, include the work of Hawkins (1974), who noted some changes in shop mathematics due to metrics. He felt that vocational mathematics courses will feel the changes of metrication most. Peterson (1977) discussed the metrics issue as it relates to a variety of occupational areas. Irving (1975) documented the basic concepts of metrics and some of the rules technical teachers will need to know to help them prepare their students for the changing world. Gourley (1976) produced a metrics course outline for use in community colleges and with other adult programs.

Gallimaufry

Large numbers of mathematics and vocational educators have worked in diverse targeted special interest areas. Exemplars include:

Women and mathematics. The special programs of women in regard to mathematics achievement were addressed by Fox (1976) and Greenberg (1978).

Learning centers. McHale, Witzke, and Davis (1969) used learning centers at the technical college level to serve average and below average students in industrial technology. Programmed instruction and teacher's aides were used to assist students described as being fast, regular, and slow learners.

Computer assisted instruction (CAI). Suydam (1969) discussed CAI and its capability to teach at the level at which each child is ready. Mitzel (1971) used CAI for curriculum development in mathematics, science, and communication skills for vocational education. Clark and Long (1974) used CAI to remedy basic skill deficiencies in secondary vocational and academic students. Hankin, Smith, and Smith (1966) described issues related to using CAI with normal, retarded, and undergraduate students.

Learning disabled. Curriculum guides which address basic skills in mathematics for elementary, junior high school, and high school EMR students have been developed by the Arkansas State Department of Education (1968) and by Ruschmeier and Rockwell (1974) of the Lake Butler, Florida EMR Curriculum Project. A curriculum guide for TMR students has been prepared by the South Dakota State Division of Elementary and Secondary Education (1974). The guide addresses science and mathematics at four levels of difficulty.

Corrections. Youth and young adults in correctional facilities have special problems which are complicated by achievement difficulties. The Pennsylvania State Correctional Institution (1968) and Miller, Sabatino, and Sloan (1975) of the Illinois State Office of Education reported on programs and materials used to alleviate deficiencies in mathematics ability for these youth.

Rural youth. Dawson (1963) spoke to the needs for basic skills in mathematics for rural youth at the National Conference on Problems of Rural Youth.

The interested reader will find much material related to mathematics, vocational, and career education. Suydam (1976) alone documented over 100 articles in the ERIC system and professional journals which related to mathematics and science in career education classroom activities.

OBSERVATIONS STEMMING FROM THE LITERATURE

The literature-related mathematics as it interfaces with vocational education is rich and varied. It is also multileveled

and international. On synthesizing such a broad-gauged information pool one may be troubled in attempts to represent it adequately. In such instances, it might be best to distill the themes woven into the literature into pertinent summary statements which have pertinence to colleagues interested in the main and nested issues. Today, the following observations and recommendations for research and practice seem to have tenability in reflecting the literature related to mathematics and vocational study.

1. Many of today's youth have deficiencies in fundamental mathematics skills.

2. The typical citizen desires that basic skill deficiencies be remedied.

3. Mastery of basic mathematics skills, at the minimum, is required for optimum success in vocational study.

4. A person's vocational development, in the long run, is inhibited by deficiencies in fundamental academic skills, including mathematics skills.

5. Support for attention to basic mathematics skills in relation to vocational study seems to be found in both the mathematics and vocational disciplines.

6. Information pools and the literature are rich with reports of activities attending to basic mathematics skills in relation to vocational education.

7. There is a paucity of rigorously defined data which document the critical relationships between specific mathematics skills and specific occupations.

8. The appeal of mathematics may be increased, and fear or apathy may be remitted, for vocational students, by demonstrating the relevance of mathematics subject matter to occupations and careers.

9. Teachers of mathematics would profit from experiences which promote awareness of the levels of mathematics required in trade and technical areas.

RECOMMENDATIONS

1. Further curricular and instructional collaboration should occur between vocational and mathematics educators to promote basic skill development.

2. Career education should be considered as a possible organizing theme for collaborating on basic skill development activities.

3. Educators in both disciplines should use their individual and collective expertise to promote developmental research related to:

   - The instrumental value of mathematics to various occupations
   - The relative effects of locus of mathematics instruction in relation to vocational education, i.e., shop, shop related, or academic classrooms
   - The effects of "relevance to vocational specialty" on mathematics achievement
   - The relationship between mastery of fundamental skills and subsequent interest in higher mathematics for nonacademic students
   - The capability of vocational teachers to impart to students a recognition of need for and desire to master mathematics skills
   - The capability of various instructional strategies to remedy mathematics deficiencies
   - The development of diagnostic instruments capable of measuring mathematics competencies critical to specific occupations
   - The critical relationships between substance and strategy in instruction designed to alleviate mathematics deficiencies

Such research will no doubt cost, but it is also likely to pay.

CONCLUSION

By perusing the ERIC collections and other pools of mathematics and vocational literature, one can ascertain that activity in the development of basic mathematics as it relates to vocational education has been extensive. Such bodies of information enable interested readers to shoplift at the idea counters provided by such collections.

To draw important implications from the literature surveyed, however, one is urged to be a selective and perceptive reader.

It has been stated that measures of quantity are the only objective and unbiased gauges of merit. Measures of quality are capable of being distorted by personal value systems. Because of that possibility, the results, actions, and recommendations documented in information pools must be made to stand appraisals of generalized value as well. Personal or institutional actions which are taken on the basis of noncapricious deliberations related to appraisal of wide-ranging value will prove to be buffering rather than buffeting to the educational community.

It will behoove educators to remember that one problem related to basic skills is regenerative. Each year new students enroll in schools and later engage in entry or renewal of vocational trainings. Consequently, new and individualized decisions to learn or not learn are made. Mathematics and vocational educators must help all students reach their maximum achievable performances at all levels of instruction. Those teachers, as well as counselors and others, must help students acquire concordance between the personal level of mathematics competence held and the levels of competence expected of them in other of life's endeavors. To do that, educators must recognize that they are capable of manipulating their students' interests, their curricula, and their instructional strategies to improve service to and development of learners. Evidence suggests that we must be willing to do so.

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